No. 48 Dec-Jan 1993

solplan review

the independent journal of energy conservation, building science & construction practice

Inside. . .

We can't live without air - its a fundamental element. The question is, how good is the quality of the air inside our homes? It will affect the health of the home environment. There are many different potential sources of contaminants in the home. We review a number of studies that have been done recently that try to answer this question. It's not a simple matter.

As we tighten our homes, are we really making the homes more energy efficient? Doesn't the need for fresh air work against us? Michael Swinton & James Reardon present another perspective on the subject.

EMR/CANMET News presents updates on the Advanced Houses program, and review of the Maison Performante in Montreal. In addition, we have a view of how activities in Canada stack up against the rest of the world.

Other items include letters from readers, information on a new resource group, TRC news, and more.

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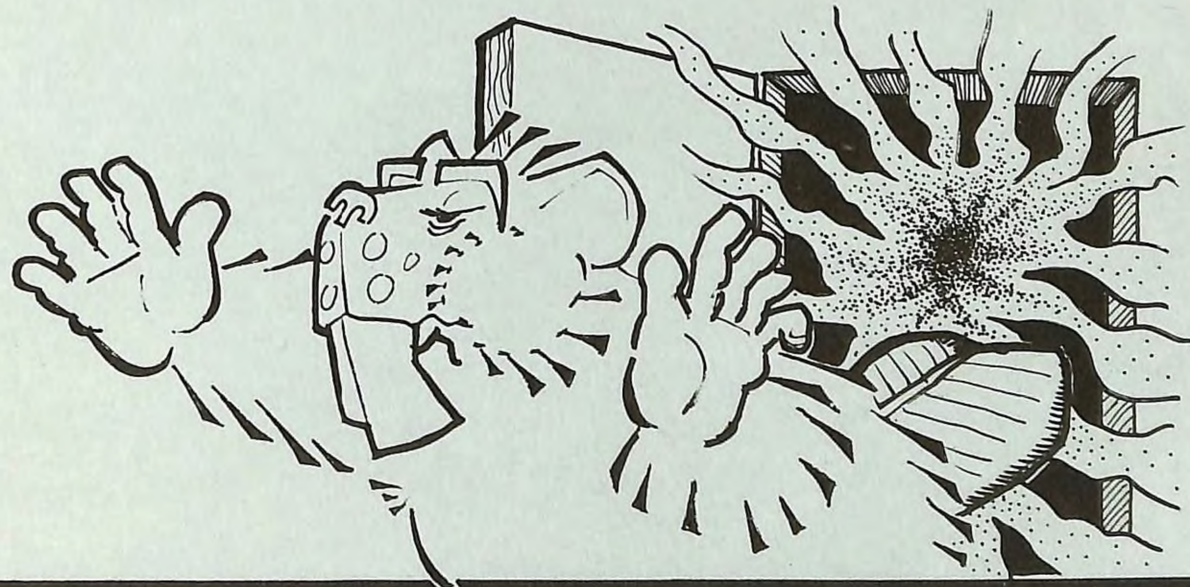

From the Publisher. . .

The start of a New Year is a time that everyone looks into their crystal balls, tea leaves, or whatever and makes pronouncements about the year to come. Usually there are many wild statements made, so I'll refrain from making such comments, but there is an observation I've noted that merits some consideration.

Pushed by special interest groups, the advent of new trading patterns and the globalization of trade, where and how we do business is changing fast. While multi-national business may seem to be the domain of multi-national corporations, even the small builder, working in a small community is affected. If the globalization of trade disrupts the local economy, as it so often does, it will impact on the builder, for if the local workforce shrinks and unemployment increases, it reduces the number of people looking for housing and renovation services. It also changes the types of products and services available and even how they are marketed.

The sad fact seems to be that the large global companies in the building sector don't seem to be very responsive to local or regional concerns for research, development and innovation. More often it's a case of "that's how we do business". Period.

If a local group undertakes a project that might advance the state-of-the-art of building technology, or want to do some research and demonstration, it seems that the small local innovative companies are the ones that get involved and contribute way beyond their abilities. By contrast, the large corporations (with their substantial R&D and marketing infra-structure) are often a flim-flam house of smoke and mirrors. They talk a lot, but when the time comes to make commitments they want to know who's going to pay, what government grants are available, etc. as they run back to head office for permission to make a move. (And the faceless corporate bureaucrats at the distant head office usually don't have a clue what's being discussed).

You may say, so what? Somewhere we seem to be loosing sight of the point behind economic activity - it's not just for the sake of perpetuating and increasing the profit margin, the GNP, or whatever, year after year, but strange as it may sound, it's there as a means, or a tool, to make this a better world in which to live and pursue our lives.

Richard Kadulski
Publisher

solplan review
the independent journal of energy conservation, building science & construction practice

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ISSN: 0828-6574
Date of Issue: January 1993
SOLPLAN REVIEW is published 6 times per year by:
the drawing-room graphic services ltd.
Box 86627, North Vancouver, B.C. V7L 4L2
Tel: 604-689-1841 Fax: 604-689-1841

Street address:
208-1280 Seymour St.
Vancouver, B.C. V6B 3N9

Second Class Mail Registration No. 6855
Postage paid in Vancouver, B.C.

SUBSCRIPTIONS: In Canada 1 year $40.66; 2 years $77.04 (includes GST). USA and other foreign payable in US $ 1 year $46.00, 2 years $88.00.
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PRINTED IN CANADA
GST Registration: R105208805

Indoor Air Quality

Indoor air quality is probably the most controversial aspect of residential building science. Since the Second World War, the product delivered by Canada's housing industry has evolved from a leaky, drafty structure which relied upon poorly understood and totally uncontrolled forces to provide ventilation, to today's house which often features draft-free construction and a sophisticated mechanical ventilation system. Countering this improvement has been the increased use of new materials which can threaten the air quality in the modern home.

The challenge for the housing industry is to identify affordable and practical measures to safeguard indoor air quality and to develop standards and systems to permit their effective implementation. We highlight several studies that have monitored aspects of indoor air quality in Canadian homes.

How good is the indoor air quality in R-2000 houses?

A three year monitoring program of 20 new houses in Winnipeg (16 R-2000 houses and 4 conventional houses) showed that the air quality in R-2000 houses is superior to that in the conventional structures. The "conventional" houses were somewhat better than the norm, as all had some type of mechanical ventilation system.

Formaldehyde, radon daughters, particulates, nitrogen dioxide, carbon dioxide and relative humidity levels were measured on a regular basis along with the total air change rates. While these contaminants represent only a small sample of the many pollutants found in residential environments, they are generally regarded as some of the more important ones.

Formaldehyde

Formaldehyde is a colourless gas with a pungent odour that is found in both the indoor and outdoor environments. It is an irritant that primarily affects the respiratory and nasal passages and the eyes. People demonstrate varying tolerances.

In new houses the major sources are particleboard, medium density fibreboard and hardwood plywood panelling. Consumer products including furniture, clothing and household chemicals also use it as a constituent of glues or coatings. Cigarette smoke is also a major source of formaldehyde.

The formaldehyde data was analyzed on the basis of the type of ventilation system. Houses with HRVs had lower levels than those with simple bathroom fans. The mean observed level in houses with central exhaust systems and make-up air ducts was slightly lower than that in houses with HRVs.

The Action Level for formaldehyde of 0.100 ppm, established by health authorities was readily achievable in the project houses. The mean concentration in the R-2000 houses was 0.060 ppm compared to 0.068 ppm in the conventional units. Significantly higher levels were noted in those R-2000 houses which were not operated according to R-2000 ventilation guidelines.

Radon

Radon is an inert, colourless gas which occurs naturally in the soil. Exposure to radon gas is acknowledged as a contributor to the development of lung cancer.

Common radon control methods include ventilation and source control to reduce entry of soil gases from the ground.

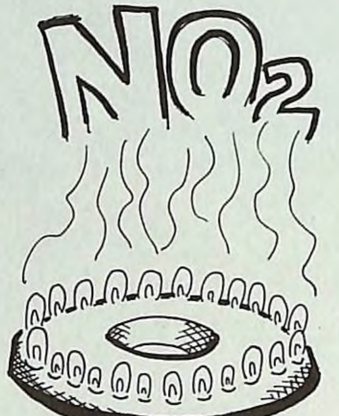
The gas enters buildings primarily by air infiltration through openings between the soil and the structure below grade level.

The Canadian guideline developed by health authorities is that action be taken when the average radon level exceeds 0.10 Working Levels (WL). The radon levels in the test houses were significantly lower compared to conventional houses in Winnipeg which had been tested in earlier studies (0.017 WL was the mean level). Radon levels in the R-2000 houses were 0.007 WL and the "conventional" houses 0.010 WL, well below the recommended action level.

Particulates

Particulates are materials suspended in the air. Household dust sources include tobacco smoke, construction materials, household products, humans, pets, plants, clothing, carpeting materials, mould, fungi, algae, wood smoke and outdoor sources such as automobile exhausts and wind borne dust. Health effects of particulates vary depending on the type, duration and intensity of exposure.

The type of heating system in the R-2000 houses had a major impact on particulate levels. Houses with forced air systems averaged 36 µg/m³ (micro-grams of particulates in every cubic meter) compared to 26 µg/m³ in baseboard heated houses. The lowest particulate concentrations were recorded in houses equipped with central exhaust systems and make-up air ducts (27 µg/m³) and the highest in houses with bathroom exhaust fans (50 µg/m³). Average values in houses containing HRVs were similar to those found in houses containing central exhaust systems with make-up air ducts (33 µg/m³).



Nitrogen Dioxide

Nitrogen dioxide is a colourless gas which is odourless in the concentrations normally encountered in residential environments. It is a combustion by-product and major indoor sources include unvented gas stoves and other combustion appliances (including wood stoves and fireplaces) as well as tobacco smoke.

Nitrogen dioxide readings were well below the recommended exposure guideline of 0.05 ppm but none of the houses had gas stoves, fireplaces, wood stoves or combustion appliances other than the furnaces and hot water tanks in the conventional houses.

Carbon Dioxide

Carbon dioxide (CO_2) is a colourless, odourless gas present in both indoor and outdoor air. It is a by-product of metabolic processes such as human respiration and by the combustion of fossil fuels. CO_2 can affect the rate and depth of respiration and produce feelings of fatigue, headaches and a general sense of discomfort.

The Canadian guideline for long term CO_2 exposure in residential environments is 3500 ppm. ASHRAE suggests a level of 1000 ppm not as a health risk indicator but as a measure for human comfort. Outdoor levels average around 320 ppm.

Over 1000 spot measurements of CO_2 concentrations were made. Only one reading exceeded 3500 ppm, and 94% of the readings were below 1000 ppm. None of the houses contained gas stoves, kerosene heaters or other major sources of carbon dioxide and average occupancy levels were two adults and one child per house.

The median CO_2 concentrations in houses with central HRV systems was 600 ppm, houses with make-up air ducts 725 ppm, and conventional houses with bathroom fans 800 ppm.

Relative Humidity

Moisture in indoor air is seldom viewed as a pollutant but if present in either small or large quantities, it can create adverse effects on the occupants and the structure.

Canadian guidelines for residential environments recommend that relative humidity levels be maintained between

30% and 80% in summer and 30% and 55% in winter (unless constrained by window condensation). 40% to 50% is suggested to minimize upper respiratory infections. Relative humidities in Canadian homes have been found to range from 21% to 68%.

Mean relative humidity levels were more commonly within the recommended winter range of 30% to 55% in the R-2000 houses than in the conventional houses.

Humidity levels were highest in the houses with bathroom exhaust fans (55% RH), followed by houses equipped with central exhaust systems and make-up air ducts (49% RH) and HRV (45% RH). The difference between houses with bathroom exhaust and houses with HRV was found to be statistically significant.

Mechanical Ventilation and Indoor Air Quality

The statistical relationship between the five measured pollutants and the corresponding air change rates were generally poor. With the exception of formaldehyde, air change rate was not observed to be a good predictor of pollutant concentration.

High air exchange rates don't guarantee low pollutant concentrations. However, it must be stressed that mechanical ventilation was necessary to achieve good indoor air quality in the study houses. Those operated at very low mechanical ventilation rates were more likely to suffer from higher indoor contaminant levels.

The findings highlight the limitations of using mechanical ventilation as the sole means of achieving acceptable air quality at the pollutant concentrations encountered. The study does not suggest that mechanical ventilation is not an important component of an effective indoor air quality control strategy, but rather that additional measures are needed. Greater emphasis must be placed on other control measures including source removal and isolation, pollutant entry control and improved ventilation system efficiency and effectiveness.

Source control should be seen as the first line of defence to protect indoor air quality.

Homeowner intervention with the mechanical ventilation systems was common and often resulted in lower than expected system utilization. Design rates used for ventilation systems, particularly those systems which do not have heat recovery capabilities, should be established both on the ability of the system to remove pollutants as well as the effect homeowner utilization will have on the net ventilation rate.

Ventilation systems with large installed capacities are likely to be used less frequently because of homeowner perceptions of increased energy costs, noise or discomfort.

Indoor Air Quality Monitoring of the Flair Homes Energy DEMO/CHBA Flair Mark XIV Project. G. Proskiw, P. Eng., UNIES Ltd. for The Buildings Group, CANMET, Energy, Mines and Resources Canada

Volatile Organic Compounds Survey

Some volatile organic compounds (VOCs) are known to be human irritants or carcinogens. The list of compounds that are classed as VOCs can be very long, and analysis of the data can get very complex because there are so many variables. The range of sources is as diverse as the range of products encountered in construction materials, furnishings, clothing, occupants, food and pets in the home.

The major contributors to VOC levels in houses can include any of the following: carpets, carpet underlays, vinyl flooring, paints, household cleaning products and waxes, cooking odours, combustion gases, textiles, tobacco smoke, moulds and fungi, human bio-effluents, hair spray, disinfectant spray, glues and wood products.

What are the VOC levels in houses?

Forty-four houses in Saskatchewan and Ontario were surveyed. 20 were in Saskatchewan (Saskatoon and Regina) and 24 in Tillsonburg, Ontario. The Saskatchewan houses were standard new houses that had been used in a 1989 *Survey of Airtightness of New Merchant Builder Detached Homes*. The houses in Tillsonburg, Ontario dated as far back as the 1890's.

Air change rates, relative humidity and temperatures were noted. For this study a total of 26 volatile organic compounds commonly encountered were individually measured. Information on specific items present in the houses that might contribute to VOC levels were also noted.

The total volatile organic compound (TVOC) levels in 100 Canadian non-residential buildings have been found to vary form 100 to 100,000 µg/m³ (micrograms per cubic meter; outdoor TVOC levels are about 100 µg/m³), but measured values in the typical Canadian office environment have been reported in the 1000 to 3000 µg/m³ range. A level of 200 µg/m³ for TOVCs has been suggested as the limit before it starts to impact people.

Only 10 of the 44 houses had TVOC readings less than 200 µg/m³, and the average TVOC reading was 555 µg/m³.

As a result of the many different compounds and materials in each house it is difficult to make accurate generalizations. However, a number of interesting relationships were observed. Careful selection and use of products can contribute to a healthier home environment.

CONDITION	HIGH TVOC READINGS	LOW TVOC READINGS
Relative Humidity	Higher (34%)	Lower (32.7%)
Air Change	Lower (0.3 ACH)	Higher (0.36 ACH)
Temperature	Higher (21.4 C)	Lower (20.8)
Age of home	Newer (1975)	Older (1969)
Particle board underlay	Greater use (40%)	Lower use (20%)
Continuous ventilation	lower use (0%)	Higher use (20%)
Paint use previous 30 days	Higher (30%)	Lower (10%)
Number of smokers per house	Higher (0.6)	Lower (0.3)
House with much worse average air quality	Worse (10%)	Better (0%)
Use of perfume	Higher (5.5 times/week)	Lower (4.0 times/week)
Use of Pinesol	Higher use (30%)	Lower (0%)

The sample size was small, so that definitive conclusions can't be made from the findings. However, some relationships were noted that may be of interest. These are summarized in the accompanying table. Low TVOC readings were 10 houses with levels less than 200 $\mu g/m^3$, while the high TVOC range were those with readings over 750 $\mu g/m^3$.

It is also worth noting that only 4 out of the 44 houses had continuously running ventilation. Two of the ten houses in the low TVOC range had continuously running ventilation. None of the houses with VOC concentrations over 750 $\mu g/m^3$ had continuous ventilation.

Volatile Organic Compound Survey and Summarization of Results by Dr. Rob Dumont and Lawrence Snodgrass, Building Science Division, Saskatchewan Research Council, for CMHC.

Illness and Indoor Air Quality

A Swedish study has confirmed that there is a direct relationship between the occurrence of colds and low indoor humidities. At lower humidities the viruses have better conditions for survival. In addition, changes in the resistance offered by mucous membranes means the body is less resistant to the viruses.

The study, done in ten day-care centres in the Stockholm area, found that 2-4 days after a period of very low humidities there was an increased frequency of illness. The same can be found with very high humidities. The lowest incidence of illness was found with indoor humidities in the 30-40% range during the coldest period.

Microbiological Pollutants in Older Houses

Older houses are often considered superior to new energy efficient houses, as the houses supposedly "breathe" and "flush out" contaminants.

Is there any truth to these ideas? Are older houses really healthier?

An in-depth study of 28 homes in Tillsonburg, Ontario was done in early 1991. The study concentrated on indoor air quality, in particular airborne moulds and bacterium. Homes were selected randomly, on the basis of the willingness of the occupants to allow researchers into the home. The age of the houses varied between 1 and 100 years, with the average age being 30 years.

Measurements of temperature and humidity, airborne fungal spores and bacteria were taken in the living areas of the houses when they were under natural conditions. An effort was made to carry out the visits during colder weather between January 15th and March 15th.

A depressurization test was done to evaluate the relative air tightness of the house. The normalized leakage area (i.e. the total leakage area per unit area of exterior building area at 10 Pascals pres-

sure difference) ranged from 1.03 to 7.91 cm^2/m^2 (the R-2000 limit is 0.7 cm^2/m^2). This is equivalent to an air change rate of 0.101 to 0.728 air changes per hour (ACH) (15 to 161 l/s). Ten of the houses averaged less than 0.3 ACH.

It is important to note that these air change rates are the real effective air changes. R-2000 builders will be familiar with the limit of 1.5 ACH which is a calculation and test done at a condition where the house is under a uniform negative pressure of 50 Pascals which in reality the house never sees.

From the human health point of view, the presence of large numbers of fungal spores in the air would more likely be associated with hypersensitivity problems, especially in patients with illnesses involving the immune system. However, none of the fungi isolated are species that are regularly associated with clinical syndromes in people. Analysis of 56 samples produced 29 different species which were considered as being prominent. 10 have been identified as "Toxigenic" or "Mycotoxin-producing".

The mechanisms which were most often found to lead to high levels of mould and bacterium were low air-change rates and exposed soil, although the existence of these did not automatically mean there were high mould and bacterium levels.

Analysis of construction features, equipment and appliances found that houses with central air conditioning and gas fuelled heating and hot water systems tended to have lower airborne microbial levels. Houses with crawlspaces, electric or sealed combustion water heating, mouldy walls and mouldy smelling basements had higher levels of mould and bacterium. The number of plants in the house had little impact on the level of mould and bacterium.

Occupants who frequently operate humidifiers and who set back the space temperature often and for longer periods of time tended to have homes with higher levels of microbial activity. Those who kept their furnace filter in good condition had more mould and bacterium than those who had filters in poor condition. (Typical furnace filters are ineffective at removing fine particles until heavily loaded with dust, when it starts to filter out smaller particles.)

Refrigerators where the defrost drain tray was not heated by the condenser or compressor were found to be sources of pollutants. Windows in general were found to be the most common source of moulds, especially bedroom windows. Basement surfaces, cold-rooms and exposed soil were also productive sites for mould and bacterium, as were bath/shower enclosures.

While there is a strong relationship between the air-change rate and the interior humidity level, no relationship between airborne mould and bacterium concentrations and the air-change rate or humidity level could be derived in a statistically satisfactory analysis.

It is normally considered a given fact that low levels of air-change contribute to higher levels of microbiological activity. This was not supported statistically by the group of houses in this study.

The premise that houses with moisture-related faults such as water leakage, damp basements or previous flooding are more microbiologically active was also not supported statistically by the group of homes in this study. Another, more extensive survey is needed to determine if this group of houses was just a fluke, or whether the basic assumptions are faulty.

The interaction of higher humidity levels, condensation and mould growth is poorly understood, ignored, or considered less important than other issues in our daily lives. In most instances where condensation and mould growth was linked to how the house was operated, such as the use of a humidifier or temperature set-back, the occupant had little awareness of the mechanism which led to the condensation and fungal growth.

In most instances the fungal growth was considered to be a cosmetic annoyance only. Where lack of ventilation was an issue, the main concern was to minimize heating costs, and to accompanying fungal growth was considered an annoyance.

"Testing of Older Houses For Microbiological Pollutants" prepared for: Canada Mortgage and Housing Corporation by: Bowser Technical Inc., with Chiron Consultants, Dr James L Whitby

Letters to the Editor

Sir,

RE: Hard-Ducted Make-up Air for Ventilation (SOLPLAN REVIEW, Oct. Nov. 1992)

I am disappointed that so much ink has been devoted to this inconclusive study. The study included three houses in which the homeowners operated the furnace fan continuously, otherwise the systems only operated the furnace fan on a demand for heating. (The article says only one house was operated continuously, is this an error in the study?)

The concern with this type of system is that if it is operating it brings in fresh air prior to burner operation so the heat exchanger will be cold. When the burner starts there will be more condensation than normal on the inside of the furnace heat exchanger and a longer ''wet time'' before the heat exchanger achieves a stable temperature. When a furnace operates in the ''heat-only'' mode, the fan-control begins blower operation only after the heat exchanger is up to operating temperature. This results in short predictable wet-times. No comparison was made between the three ''continuous'' homes and the others.

The study did not state whether the furnaces were ''standard'' efficiency equipment or not. The reality of the Ontario and B.C. market-places is that all new gas furnaces are mid-efficiency. Gas furnaces manufacturers have recommended that furnace mixed-air temperatures not be allowed to fall below 15.5°C for mid-efficiency furnaces. The report's discussion of 13°C return air design temperatures without discussion of the furnace manufacturer's return air temperature limitation is a glaring omission.

The discussion of mixed air temperature and delivered air temperature is based on calculation only, not field observation. There was no measurement of actual delivered air temperatures in the study. It may have been nice to know what the air temperature gain was at the register as opposed to at the return, when the furnace is operating in a non-heating cycle.

A glib reference is made to the use of an electric duct heater for pre-heating. I am aware of only one heater which is suitable for this purpose, as all others could be safety hazards due to the lack of protection from the condensate formation on bare live elements.

In the Ontario sample of 13 homes, 11 were essentially identical town-homes, all having the same installation and design faults. The remaining two were equipped with automatic dampers which only opened on the temperature rise of the furnace during combustion cycle. Thus the conclusions concerning the lack of insulation and the understanding of the installing contractors is based on a very small sample.

With regard to the study's recommendation for the location of outside air duct connections, it is not clear whether this is based on speculation or the result of field observation. No measurements were made of return and outside air mixing (or lack thereof).

The study and article go beyond the scope of the study and the field observations when they state ''*Despite the extensive training sessions provided to contractors by HRAI, a visit to many houses being built in accordance to the new Ontario Building Code indicates that some designers and installers have little or no understanding of basic physics, air movement or ventilation. Better and more training courses delivered by knowledgeable trainers may help.*''

This statement implies that the installations witnessed in OBC complying houses were badly carried out even though the contractors had been trained, and that most contractors have received HRAI training in ventilation. Nothing could be further from the truth. The HRAI ventilation courses are voluntary, except for ventilation system installers for R-2000 houses. (Perhaps this training should be mandatory for installers and Building Officials alike).

Many contractors and most technicians in the Toronto-area new-home market have not received ventilation training. The ONHWP ''Speaking in Code'' Seminar series does not even mention the availability of HRAI training and the book ''How Not to Install a Ventilation system to comply with the Ontario Building Code'' does not mention or recommend the HRAI training program.

When Mr. Geddes goes on to question the installing trades' understanding of physics, air movement and ventilation, he does a disservice to the industry in which he is a participant. Personally, I think the quality of installations witnessed by Mr. Geddes has a lot to do with the installer's understanding of the client's requirements; i.e. spend as little money on it as possible. The attack on the quality of HRAI's ventilation courses and material can't be based of fact. Concerning my fellow instructors in Ontario, Barrie Bowman and Mike Lutman, I can't think of more knowledgeable or practically-oriented persons. The quality of the training course has been constantly improving, and contains current information. I can't see how Mr. Geddes is qualified to make such a statement, not having attended a course.

That Mr. Geddes would go beyond the scope of the study to make these statements with respect to HRAI's training program; which statements are not supported by any measurement, survey result or experience is reprehensible. The conclusions and recommendations which are found in the study are an effort to put a brave front on an inconclusive work. Casual readers may be seriously misled by the quality of the conclusions.

Your readers deserve much better quality than this.

Dara G Bowser,
HRAI Ventilation Instructor
Brantford, Ont.

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BACK ISSUES SPECIAL
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RESIDENTIAL VENTILATION: Achieving Indoor Air Quality

The original Canadian book that tells designers and builders how to deal with indoor air quality issues. It describes why ventilation is necessary and how it can be provided, effectively and without creating discomfort.
Key principles of ventilation systems are laid out in very simple language. By Richard Kadulski, illustration by Terry Lyster, technical consultant David Hill

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Sir,

I have been asked to write on behalf of the HRAI Executive in support of a letter from Dara Bowser concerning the "Hard Ducted Make-up Air for Ventilation" article in the October/November, 1992 issue of Solplan Review. Mr. Bowser is only one of a large number of HRAI members who found the results of the CMHC study to be inconclusive and misleading. We also share the opinion that remarks in the report concerning HRAI training are outdated, incorrect and simply inappropriate. It is most unfortunate you would choose this questionable report to highlight in Solplan Review.

For these reasons, we strongly urge you to allow your readers to understand the short comings of this CMHC study.

Warren J Heeley, B.A.
President, HRAI
Toronto, Ont.

Sir,

RE: Hard-Ducted Make-up Air for Ventilation (Solplan Review, Oct. Nov. 1992)

The article states "The connection must be downstream of all other return air branch connections..." I've thought about this and can't think of any technical reason why.

It also states that "it is difficult to calculate the amount of tempering that may occur and the resulting air temperature at the furnace."

It is very easy to calculate the amount of tempering, and the resulting air temperature. You need to know three things: furnace fan capacity (cfm) which can be calculated from the Btu/hr rating if you don't know the cfm.

$$\text{cfm} = \frac{\text{Btu input x furnace efficiency}}{75.6}$$

The 75.6 is based on the furnace heating the air through a 70°F temperature rise. Use 86.4 for an 80°F temperature rise.

If:

X = furnace fan capacity (cfm)
A^0 = mixed air temperature to the furnace (^{0}F)
Y = fresh air (cfm)
B^0 = fresh air temperature (^{0}F)
70^0F = return air temperature

then $X*A^0 = Y*B^0 + 70*(X-Y)$

and

$$A^0 = \frac{[Y*B^0 + 70*(X-Y)}{X}$$

For example:
if X = 425 cfm
Y = 80 cfm
B = +10 °F

then

$$A = \frac{[80*10 + 70(425-80)]}{425} = 58.7\ ^\circ\text{F}$$

George Pinch, P.Eng
B.C. Hydro
Vancouver, B.C.

EcoDESIGN Resource Centre

With the renewed interest in environmental issues it's sometimes difficult to sort out the truth between media hype, manufacturer's claims and special interest group claims. We hear a lot of buzz words but it's often difficult to get the facts.

Everything we do has an environmental cost and may be toxic to some degree. When we make materials choices, we have to maintain a balance so that environmental and health costs are minimized and real benefits realized. Better selection of materials can mean less impact on the earth and more healthy built environments.

Professionals in the building industry, be it at the design stage or in the field, must move beyond the environmental clichés and start using information regarding human and environmental health and in their work. But where to start? How does one analyse the conflicting claims?

One attempt to help sort through the maze of information is being set up in Vancouver. The EcoDESIGN Centre, a not-for-profit organization being formed, aims to be a forum for discussion of topics dealing with design and its relation to the environment. It plans to set up a library, an information centre and meeting room for seminars. The project is still in early development stages, but response has been enthusiastic among professionals, the public and potential sponsors. The centre will be funded in part by memberships, and will include a quarterly newsletter, workshops, seminars, tours, and possibly a bookstore.

This project, the initiative of Shelley Penner, an interior designer, and Keith Jakobsen, a graduate architect, is still in early development stages. We will keep readers informed of developments as they progress. If you want more information, contact SOLPLAN REVIEW and we'll forward your queries.

Air Tightening New Houses For Improved Energy Efficiency - What Is The Potential?

M.C. Swinton and J.T. Reardon

In the last ten years, construction practice has evolved in response to the need for reducing air leakage through the building envelope of houses. As a result, new houses are being built more airtight. Recognizing this fact, the 1990 National Building Code (NBC) requires a mechanical ventilation system capable of producing 0.3 air changes per hour, thus providing a mechanical means of achieving minimum ventilation levels when needed. With only a few regional exceptions, builders have been meeting the intent of the mechanical ventilation provisions of the NBC with exhaust-only fans - typically kitchen and bathroom fan combinations.

Given these developments in NBC requirements, recent trends in house design, and the need to achieve energy efficient construction, the following questions arise:

* How energy efficient is current house construction with respect to overall air change?
* Can we achieve additional energy efficiency, without compromising minimum ventilation requirements?

As the debate on getting the right balance between airtightness, ventilation, energy cost, and first cost of a house has been going on for some time in Canada, most readers will have an opinion - and likely a strong one - on how the questions should be answered.

Those who argue that houses are already being built tight enough refer to improvements in building practice in recent years, increasing occupant complaints relating to indoor air quality and the offsetting energy costs of operating fans for additional ventilation over a greater proportion of the time. Those who argue that even tighter envelopes are needed cite the success of the R2000 approach which controls excessive air leakage during cold or windy periods with a tight envelope, provides better air quality through a controllable mechanical supply of fresh air and saves energy with heat recovery ventilation, thus offsetting higher first costs.

The arguments are compelling on both sides, in part because each can be right for different circumstances - conditions that vary throughout the heating season and from location to location. In cold and windy weather a tighter envelope reduces cold drafts and excessive heat loss, as well as condensation within the construction. In moderate winter conditions, the appeal of a 'passive' ventilation system, i.e., air leakage that delivers adequate fresh air at no additional cost has some attraction. What really can't be determined through general debate is the degree to which each of these conditions persist throughout the heating season.

In an attempt to provide quantitative information on the subject, the Institute for Research in Construction (IRC) undertook an investigation to determine the range and distribution of conditions and air change rates experienced by typical new houses in various locations across Canada. The 1989 cross Canada survey of airtightness levels in 200 new tract-built houses provided some of the information needed. A computer-based simulation model of infiltration and ventilation, developed at IRC, was used to investigate air leakage rates for typical ranges of airtightness levels and weather conditions found across Canada.

The study results indicated that leaky houses often experience excessive air leakage during a significant part of the heating season. For example, a leaky house in a cold prairie climate (leaky by today's standards, with a normalized leakage area, NLA* = 2.1) might have air leakage rates of 0.4 air changes or more per hour for up to 1500 hours or 30% of the heating season. These high air leakage rates occur during the coldest winter weather. For most occupancies, this level of air leakage could be uncomfortable and expensive to heat. On the other hand, this house would have low air change rates (e.g., 0.2 air changes per hour or less) only 20% of the time - generally in calm and mild weather. For this house, providing additional ventilation during these calm periods would be a trivial task, easily addressed by a manual-control exhaust-only fan system, or opened windows.

The airtightness survey results indicate that most new houses today are not as leaky as previously thought, especially in the prairie provinces. For example, a house with an NLA of 1.5 cm²/m², i.e., 30% tighter than the house in the above example, would still be leakier than the average new market house in Winnipeg. Such a house would not experience excessive air change over the heating season (no occurrences of 0.4 air changes per hour or more). However, the tighter house's occurrence of low natural air change (0.2 or less) would increase to 70% of the time. Depending on occupancy needs, mechanical ventilation could be needed more often. This pattern of results was found for houses surveyed right across Canada, with the exception of Vancouver houses which were found to be generally leakier.

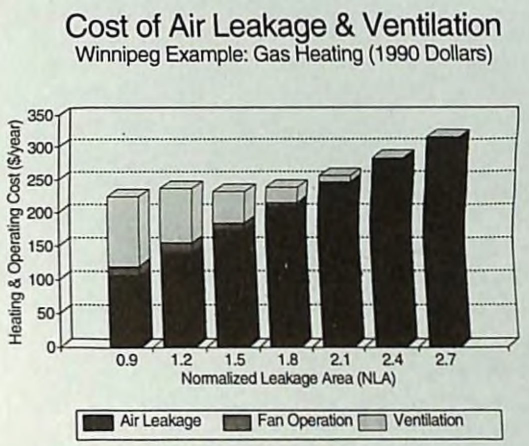
* The normalized leakage area, NLA, is a measure of envelope leakiness, as determined by a standard airtightness test. 1.5 cm²/m² was the average for houses in the 1989 survey; In some areas (such as coastal B.C.) houses are much leakier. 0.7 cm²/m² is the R-2000 limit.

The analysis was extended to calculate the total energy costs of air leakage and exhaust-only ventilation over the heating season. This is difficult to simulate with confidence because the actual ventilation needs of a given household are not constant, varying with the comings and goings of the occupants and their activities in the home.

For this study, the following scenario was assumed: a family of three living in an average size house would require at least 0.25 air changes per hour (ach) when all were at home during the evening and overnight, and at least 0.1 ach when only one person was present during the day. These levels were not based on any standard requirements nor was consideration given to the effect of indoor contaminant emissions from sources such as construction materials and sealants .

For simulation purposes, when air change rates due to air leakage fall below these arbitrary minimums, one or two exhaust fans are turned on as needed. The computer program keeps track of all fan operations and ventilation flow rates, as well as the associated energy and dollar costs of each.

As would be expected, as the house gets tighter, the cost of additional ventilation using exhaust-only fans goes up while the energy costs associated with envelope leakage goes down. However, these two opposing effects start to balance out at the leakier end of the spectrum of today's construction; i.e., the total energy cost remains essentially constant and the energy savings are much reduced or nil for envelopes with NLA's below the thresholds identified for each location.



For example, in Winnipeg the threshold NLA was 1.5 cm²/m² (see figure). This suggests that if the assumptions for fresh air requirements used in our analysis are reasonable, it could be concluded that the majority of builders' homes surveyed that had exhaust-only systems have achieved the energy balance between envelope tightness and ventilation.

As air sealing techniques become more effective (a trend that should continue for improved quality, durability and comfort), builders should consider more sophisticated ventilation systems such as low-flow continuous systems, heat recovery ventilators, or automatically controlled systems; e.g. demand-control ventilation. The effectiveness of these options should be investigated for various levels of envelope airtightness. It's becoming clear that if additional energy efficiency or air quality is sought in new construction, more stress on the ventilation side is needed, as the tighter the building envelope becomes, it is mechanical ventilation - not air leakage - that becomes the dominant energy loss component of air change.

The electricity cost of running ventilation fans was estimated to be less than 10% of the total cost of air change, even when run continuously, and even in locations where cheaper natural gas is used for space heating.

To answer the questions posed at the beginning of this article, it appears that most new homes are quite efficient relative to what can be achieved with manually controlled exhaust-only systems. Further air tightening without consideration for more efficient mechanical ventilation may not save more energy. The dilemma is that the quantities of energy involved in air change are still substantial - easily one third of the total energy bill of a typical new house. This suggests that further opportunities for improving energy efficiency for the air change component of new houses would be found in more efficient ventilation systems.

A shift to better planned ventilation appears to be happening already in many parts of the country, and codes and standards are currently being reviewed to reflect these trends. With more efficient ventilation systems in place, the feasibility of further envelope tightening will depend on the costs and benefits of the overall tightening/ventilation strategy. Finally, there is a need to encourage the universal adoption of good air barrier practices in order to eliminate those few remaining leaky houses still being built.

Michael C. Swinton, M.Eng. and James T. Reardon, Ph.D.
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, K1A 0R6

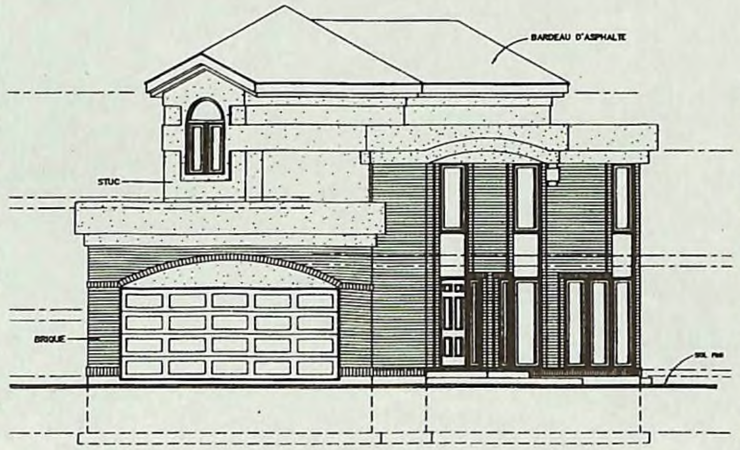
EMR/CANMET NEWS

The Canada Centre for Mineral and Energy Technology (CANMET) is the research and development arm of Energy, Mines and Resources. EMR/CANMET's Buildings Group works with industry to develop and commercialize the technologies to make Canadian houses more energy efficient. With the support of the Buildings Group, Solplan Review presents this information on some current CANMET projects. For more information contact: Energy Efficiency Division, EMR/ CANMET, 580 Booth St., Ottawa, K1A 0E4.

This month a number of items on advanced housing technology, including a look at the ten Advanced House competition winners, and the international scene for a report on what other countries are doing in the advanced house area.
If a conclusion can be drawn from this "news from around the world" feature, it is this: The Advanced House programme, with its focus on energy-efficiency and environmental responsibility is a forerunner of where housing is headed in the nineties and beyond.

Maison Performante

Maison Performante, the last of the ten Advanced Houses, broke ground on December 7. Plans for the house have undergone significant revisions since the first blueprints were drawn up - including a change of location from Longueil to Laval. However, the philosophy behind the house design remains the same - to build an energy-efficient home that does not appear overly-sophisticated to a potential homebuyer. Some of the features of Maison Performante include:



Passive Solar Heating - Ground Source Heat Pump Combination

The Advanced House Technical requirements demand that total purchased energy be 50% less than the energy required by an R-2000 home of similar size. To meet this requirement the designers of Maison Performante are using solar energy to a significant degree - approximately 35% of space-heating needs and all DHW needs will be realized through a large sun space and roof-mounted solar collectors.

Excess heat energy is collected and stored in a 10,000 litre cistern located under the garage. That 'energy' is then extracted by a ground-source heat pump (GSHP). The concept is to keep the cistern as cool as possible (without freezing the water) to enhance heat transfer. When the water in the storage tank falls to 4°C, the GSHP will revert to its more conventional mode, extracting heat directly from the ground. In the summer, the GSHP will transfer heat from the house to the ground, but without the use of the compressor, as a further aid to reducing purchased energy costs.

Insulation & Environmental Targets

The technical requirements also include a number environmental targets, such as a 50% reduction in water consumption, and the use of recycled materials. As part of Maison Performante's environmental strategy, recycled cellulose insulation will be used in above-grade walls, and on the interior of below-grade walls. (The exterior of the below-grade walls will be wrapped in 2 3/8" of expanded polystyrene. Total insulative value for the basement walls is R-22. The basement will also be dampproofed using recycled materials.)

Other parts of the strategy include the use of a wallboard containing recycled newspaper, and an extensive plan for the recycling of construction waste materials.

Home Automation

Many of the Advanced Houses have achieved significant reduction in energy use through the intricate management of electrical loads by means of home automation systems - and Maison Performante is no exception. The house will feature the first application of the IDIL home automation system designed by a Quebec-based company. Like other home automation systems, IDIL will monitor the performance of appliances and mechanicals and control electrical load for peak management purposes. Unlike most other systems IDIL does not require any special cable, utilizing normal power cable.

Maison Novtec on Track

Project coordination of Maison Novtec has recently been solidified under the guiding hand of SIRCON, the non-profit technology transfer corporation associated with the Centre for Building Studies at Concordia University in Montreal.

"The management of the project required streamlining," says Paul Fazio of SIRICON, the new project coordinator, "and under SIRCON the project is rocketing ahead."

The changing of the guard has not changed the project in any fundamental way. All of the original players are still involved. Nor has the excellent technical design been altered. However, in keeping with SIRICON's mandate of technology transfer, the communications aspect of the project is to be vastly improved.

"We're going to draw on our technology transfer knowledge and develop specific tools for communicating the results of the Advanced House project to students, the trades, the professions such as architects and engineers and to the manufacturers" says Fazio.

Look for a Christmas completion date for phase one (the Advanced House) of the two phase project and a public opening in the spring.

An Agreeable Task

Task 13 of the International Energy Agency's Solar Heating and Cooling Programme has reached the half-way point in its allotted life span and initial findings of the programme should begin to appear in the coming year.

Started in 1989, Task 13 was formed to encourage international collaboration on the design of low-energy residential buildings. Under the programme fourteen countries, including Canada, were to design, build, monitor and report on at least one low-energy structure. The group meets twice a year to discuss and critique ideas and to share information on the success (or failure) of designs and technologies.

Country	Building Type	Heated Floor Area (m^2)	Construction Status
Austria	Undecided	-	-
Belgium	Row House	-	Late 1992
Canada	Single Family	408	Completed
Denmark	Row house 1	105	Late 1992
	Row House 2	98	Late 1992
Finland	Single Family	166	-
Germany	Row house	175	-
	Duplex		-
Italy	Multi-unit	-	1993
Japan	Single Family	125	•
Netherlands	Multi-unit	95	•
Norway	Row house	142	-
Sweden	Single family	114	-
Switzerland	Undecided	-	-
United Kingdom	Housing Retrofit	-	Renovation Started
United States	Single-family	125	1993

Canada's entry in the programme was the original Advanced House built in Brampton, Ontario. "We were fortunate with the Brampton House," says Steve Carpenter of Enermodal Engineering in Waterloo, Ontario and Canada's representative on the Task 13 panel. "The House was already under construction when the Task 13 programme was initiated, so we had a lot of 'hard' information to bring to the table."

Carpenter confirms the widespread impression that Canadian builders are some of the best and most advanced when it comes to low-energy housing. ("It's our hostile climate. And if it doesn't work, you find out fast!") However, he also says that we have a lot to learn from our global counterparts, particularly in area of design.

"We are very much caught up in the 'monster' home syndrome - largely because we measure things in terms of wealth. In most other countries, the measuring stick is lack of wealth. The viewpoint that other countries bring to the table can make you re-think how you view the form and function of housing."

Task 13 representatives from many of the other member nations will be speaking about their projects at the Innovative Housing '93 conference.

Innovative Housing '93

Canada is acknowledged as one of the world leaders in the design and construction of energy-efficient and environmentally responsive housing. Still, we're not the only country that's "pushing the boundaries of the envelope." Just where and how that envelope is being pushed is the focus of Innovative Housing '93 - a five day conference to be held in Vancouver, British Columbia, beginning **June 21, 1993.**

"The conference is being sponsored by EMR/CANMET and CMHC" says Darinka Tolot, the conference coordinator, "and will be a spectacle of what is happening in housing around the world in terms of design and technical advancements."

The conference will be organized around four themes:

1. **Technological Innovations:** advanced building envelopes; electrical efficiency; advanced mechanical systems; healthy indoor environments; and resource usage efficiency.
2. **Design and Planning Innovations:** unit design and site planning; and community planning.
3. **Demonstrations and Applications:** projects such as EMR's Advanced Houses program; CMHC's Healthy House Competition; IEA Task 13; R-2000; plus others from key innovators in advanced housing technology such as Germany and Japan.
4. **Programs, Policies, and Regulations:** international research and development programs; technology transfer methodologies; DSM and retrofit programs; and regulatory and policy approaches from around the world.

The conference will feature 75 keynote speakers as well as "two hundred papers and posters from twenty-five different countries which will add colour and flavour," according to technical coordinator Terry Robinson. (Over 330 abstracts have been received to date.)

Robinson suggests that the Canadian building community will be surprised and intrigued by some of the things that other countries are experimenting with, such as zero energy houses, photovoltaics and transparent insulation.

For more information on the conference, or to obtain a registration package, contact: Darinka Tolot, CANMET, 580 Street - 7th Floor, Ottawa, Ontario, K1A 0E4.
Phone (613) 943-2259
Fax (613) 996-9416.

Technical Research Committee News

Canadian Home Builders' Association

TRC In action: a case study

We've reported on the many concerns surrounding residential fire sprinklers. This is a case study how the TRC technical network was successful in resolving a potential problem for builders and home buyers alike.

The CHBA national office was contacted by a municipal engineer in the City of Thunder Bay regarding proposed fire sprinkler regulations being prepared by his office for City Council. He was looking for technical information on the issue developed by TRC.

The sprinkler kit was provided to him, along with information and contacts at the local HBA in order for them to consider all aspects of the issue.

CHBA National proceeded to notify the provincial and local HBA representatives and to provide them with the documentation developed by TRC. As a result, Bruce Clemmensen, TRC Chairman, was asked to make a presentation to the City Council. Based on the information presented, the motion was defeated and alternative plans are being studied.

The fire chief thanked Bruce for his presentation because the information he relayed to the City Council also highlighted all the other services the fire department provides.

One of the big arguments made by sprinkler proponents is that the cost for fire fighting protection can be reduced and fire halls shut (or provided at a lower density) as the sprinklers take care of fires. What is generally overlooked in this discussion is that the fire department provides a wide range of education, prevention and emergency services. They are the emergency response team for many situations other than fires. Even where a fire has been controlled by a sprinkler it will require a response from the fire brigade. (They respond to all calls, without asking if there are sprinklers in the building.)

National Building Code Review

The National Building Code review process for the 1995 version is in its final stages. As this is the model code for all provinces, any suggestions for changes should be made to the Canadian Codes Centre, Institute for Research in Construction, National Research Council of Canada, Ottawa, Ont. K1A 0R6.

It won't do to say the whole code stinks and should be re-written. The more specific the proposed change, with a reason why the change is being proposed, the quicker the processing and evaluation.

IRAP Program

The National Research Council of Canada has as one of its main goals to work directly with Canadian firms of all sizes to develop and apply technology for economic benefit. One of its major programs to achieve this goal is the Industrial Research Assistance Program (IRAP). A major component of this program is a technology network of field advisors called "Industry Technology Advisors" (ITA's). The ITAs are strategically located in associations, provincial research organizations and private research organizations. They basically provide access to free technical information and an opportunity for small and medium size companies to conduct research and development with some contribution assistance of federal dollars. The drywall discoloration work and the current furnace depressurization testing previously reported in Solplan Review are two projects IRAP has assisted with. One ITA is located at the CHBA National office with the specific task of supporting the activities of the Technical Research Committee. His name is Ross Monsour and he can be reached at the following address:

Canadian Home Builders' Association
Suite 200 - 150 Laurier Ave. West
Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214

Any questions or concerns dealing with the technical side of residential construction may be directed his way. If he doesn't find the answer he will link you up with someone who does or your local ITA.

If you are working on a new product that still requires some development work, the IRAP program is very approachable and could be the avenue to get you some assistance.

You asked us: about Fresh Air Ventilation Systems

We are a small custom home builder in the Toronto area. We have been asked by our clients about the usefulness and practicality of the fresh air systems now required under the Ontario Building Code. Our HVAC contractors have not been very helpful in providing answers.

1. Is a central power humidifier required in the winter months? What role, if any, does the vanEE system play in the maintenance of house humidity levels? The concern is for the extensive use of hardwood flooring and expensive wood furniture, in addition to health implications.

The ventilation system is designed to operate continuously, to maintain a constant flow of fresh air for the occupants. The ventilation system lowers humidity levels in the house because as it brings in fresh outside air (which has a low absolute moisture content), it exhausts stale indoor air with its higher moisture content. This has the effect of lowering the moisture content in the house (and thus the relative humidity). During the very cold winter periods when the temperatures drop far below zero, the greater the exchange of outdoor air with the indoor air, the greater the drying effect. This is why in winter we so often encounter very dry indoor air - indoor humidities of 5-10% are possible. This is very noticeable in leaky (drafty) houses which have a lot of natural air exchange that is enhanced by natural(stack effect) driving forces created by temperature differences between inside and outside.

The optimum humidity level for human health and comfort is in the 40-55% range, but during the coldest periods of the year, to reduce the detrimental impact on the structure (reduce window condensation, etc.) a relative humidity of 30% is considered acceptable. This is why in cold areas humidifiers are introduced to counteract the drying effect of air exchange. In a tight, energy efficient home with continuous ventilation it may still be appropriate to introduce a modest amount of humidification but only during very short periods of time.

The humidifier should only be run when it becomes too dry, and then only when the system is running at slow speed. Otherwise, it should be turned off and the ventilation system run at the slowest speed.

2. What effect does this system have on summer air conditioning requirements?

The ventilation system will add to the air conditioning load in the summer, but it will provide better air quality in the home. During the summer there are no (stack effect) driving forces, meaning there are is no passive air exchange, so summer ventilation needs are higher.

3. Would increasing the house insulation to R-24 have any effect on the heating or air conditioning requirements?

Increasing insulation will reduce the heat load on the house during the winter and reduce cooling loads somewhat. However, summer cooling loads are more influenced by the design of the house and window location (which is a major factor in heat gains into the house); i.e. what types of windows are used, what elevations they are located on, and what type of shading there is on the windows. For example, large west facing glass areas that have no summer shading (as could be provided by trees) will substantially add to summer cooling loads.

Mechanical ventilation systems, when properly installed and balanced, ensure good indoor air quality in the home throughout the year. But it must be stressed that a poor installation may not provide any benefit of fresh air.

A further benefit for home owners is that they will always have better indoor air without having to resort to keeping windows open, etc. - which in urban areas also deals with security concerns. Because better indoor air quality is maintained with all windows closed, the house will also be more quiet, as less traffic noise penetrates into the house.